March 2016, Bandung

Energy Landscape

Pre-workshop course ITB

Kees van den Ende

Cooperating companies and universities

INAGA

IF Technology

DNV GL

Institute Teknologi Bandung

Delft University of Technology

Department of Geo-Technology

University of Twente

Faculty of ITC

Universitas Gadjah Mada

Universitas Indonesia

University of Utrecht

Faculty of Geosciences – Department of Earth Sciences

Netherlands Organisation for Applied Scientific Research

IND coordinator:

INAGA

NL coordinator:

ITC

Advisory board:

BAPPENAS (chair)

MEMR

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Min. Foreign Affairs NL

Rector ITB

Rector UGM

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INAGA

Funded by

Ministry of Foreign Affairs of the Netherlands

DNV GL unifies strong brands and extensive energy expertise to maximize customer value

Delivering the industry's most comprehensive set of advisory and testing, certification, and grid integration / storage services and software tools.

DNV GL
Organized to maximise customer value: Building Trust!

MARITIME

OIL & GAS

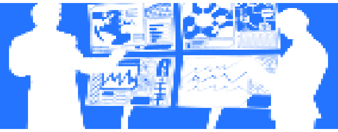
ENERGY

BUSINESS ASSURANCE

SOFTWARE

MARINE CYBERNETICS

RESEARCH & INNOVATION



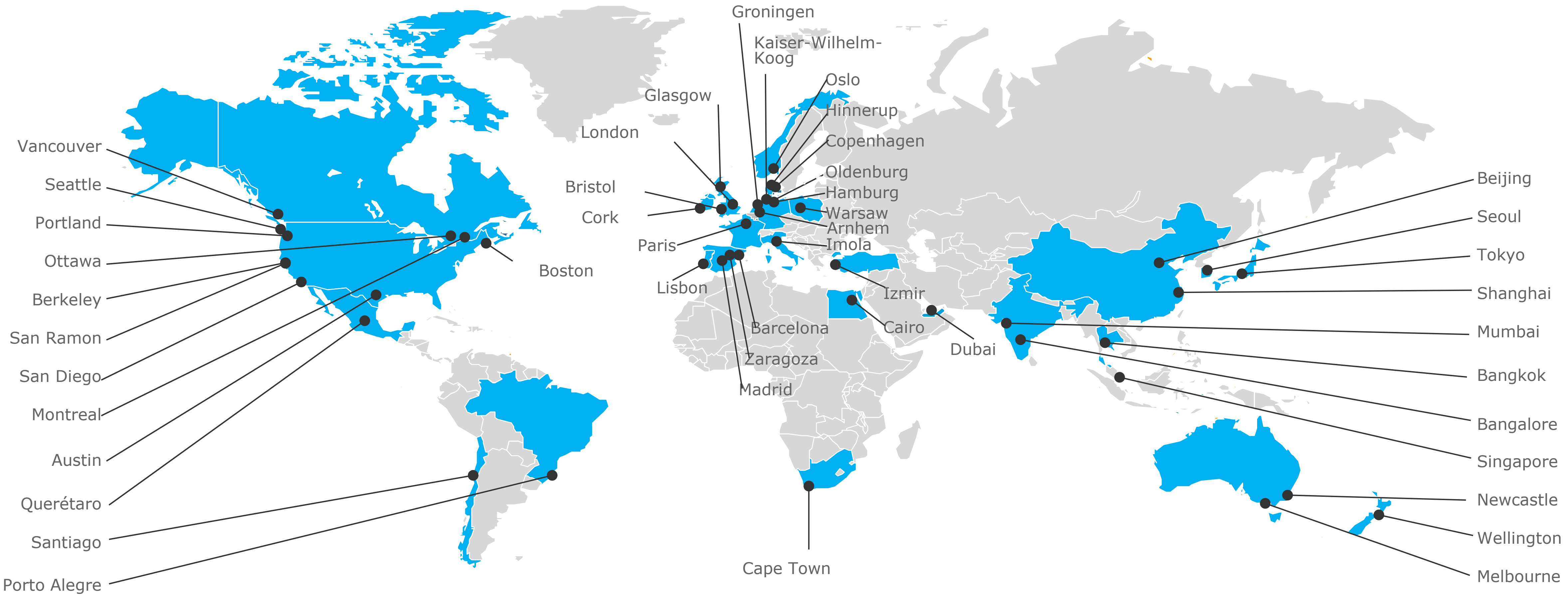
The DNV GL Group | Organizational chart

DNV GL Group
Headquarter: Oslo, Norway

Maritime	Oil & Gas	Energy	Business Assurance
▪ Headquartered in **Hamburg, Germany** ▪ 5,600 employees ▪ 80 countries	▪ Headquartered in **Høvik, Norway** ▪ 5,800 employees ▪ 30 countries	▪ Headquartered in **Arnhem, Netherlands** ▪ 2,500 employees ▪ 30 countries	▪ Headquartered in **Milan, Italy** ▪ 2,000 employees ▪ 50 countries

Our geographical reach in renewables

More than **1,000** renewables staff in **50** locations across **27** countries



Our services span the energy value chain

Policy | Production | Transmission & distribution | Use

- Power testing, inspections and certification
- **New energy technologies and storage advisory**
- Renewables certification
- Electricity transmission and distribution
- Smart grids and smart cities
- Energy market and policy design
- Energy management and operations services
- Energy efficiency services

Assisting companies in solving the energy trilemma

DNV·GL

DNV GL
Geothermal energy

IRENA
Timing: August 2013 – September 2013
Project name: Environmental impact of large scale geothermal heat and power production
Description: Assessment of the global and local environmental impact of large scale geothermal heat and power production and the available mitigation options.
Tasks performed * Identification of the main environmental impacts for each geothermal project phase. Both quantitative (e.g. CO_2-equivalent emissions) and more qualitative (e.g. visual impact and induced seismicity)
* Mitigation options for the most important environmental impacts
* Assessment of the global developments of geothermal heat and power.

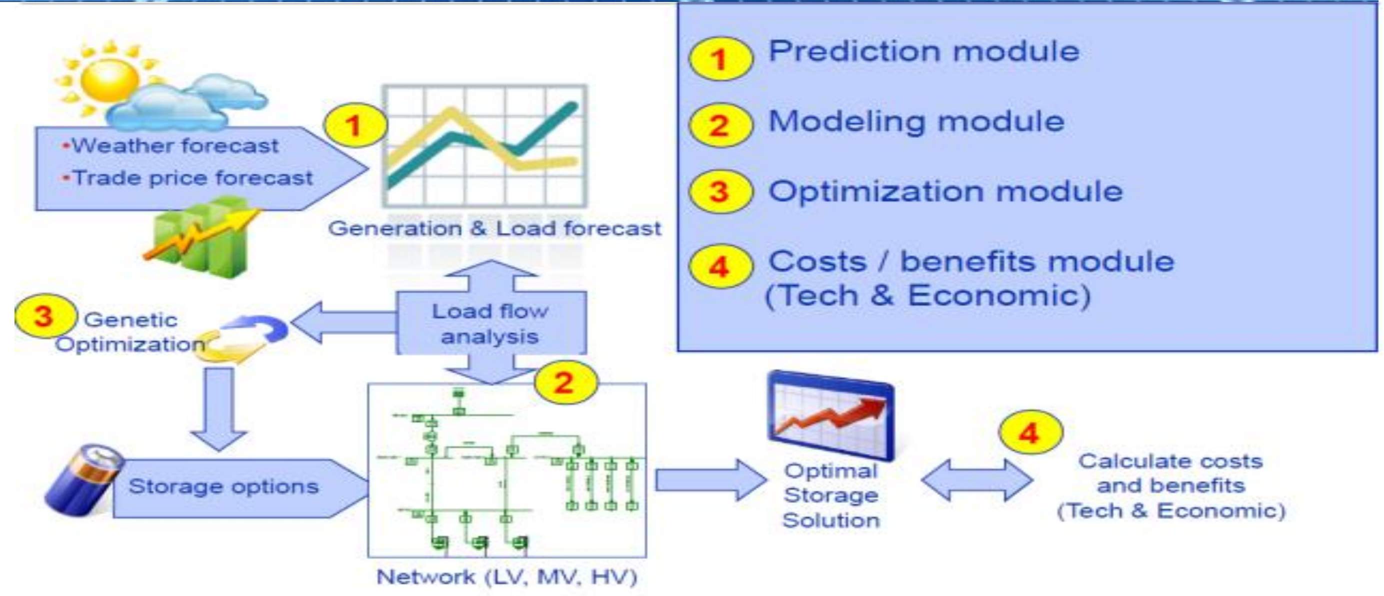
Turkish bank
Timing: June 2013 – July 2013
Project name: Technical Due Diligence of a Turkish Geothermal Power Plant
Description: Technical due diligence of a 30 MW geothermal power plant in Turkey.
Tasks performed * Review of the conceptual design: component and materials selection
* Review of energetic design: gross/net efficiency, power rating and impact of ambient temperature
* Identification of main project risks and mitigation options.
* Evaluation of the expected operational aspects: reliability, availability and maintenance requirements

Gemeente Hoogeveen (consortium with TNO and IF Technology)
Timing: June 2011 – December 2011
Project Name: Towards Demonstration of ultra-deep Geothermal Power in Hoogeveen
Description: * KEMA examined the available options for power generation at this temperature level and has made a conceptual design of the total surface parts of this system.
* DNV GL was responsible for providing a conceptual design of the surface part of the geothermal system: the geothermal power plant and integration of a district heating network connecting a nearby residential area and several greenhouses.
* This conceptual design included a economic analysis of the available options of direct heat use and different power plant designs as well as optimizing the flexibility of the power plant to cope with different possible production rates of the geothermal wells.
* The cost estimations are broken down to investment, operational and maintenance costs and a sensitivity analysis is performed to determine the impacts of the most important design and economic parameters.

DNV GL
Solar Storage System Sizing, Design and Analysis Tools

Software tool suit

- Sizing of storage
- Design (control algorithm and technical specifications)
- Analysis (energy through-put, life time)
- Market and technical aspects, covering entire chain of electricity transport and distribution
- Application area: integrated DG-related grid issues
- Maximizing renewable energy supply
- Minimizing system cost of ownership tailored to local conditions



DNV GL
Energy storage services

Impact
- Technology and Market assessment
- Business case analysis
- (Grid) Modelling
- Due Diligence
- Technology selection

Performance
- Modelling
- Testing
- Power Failure Investigation
- Inspection

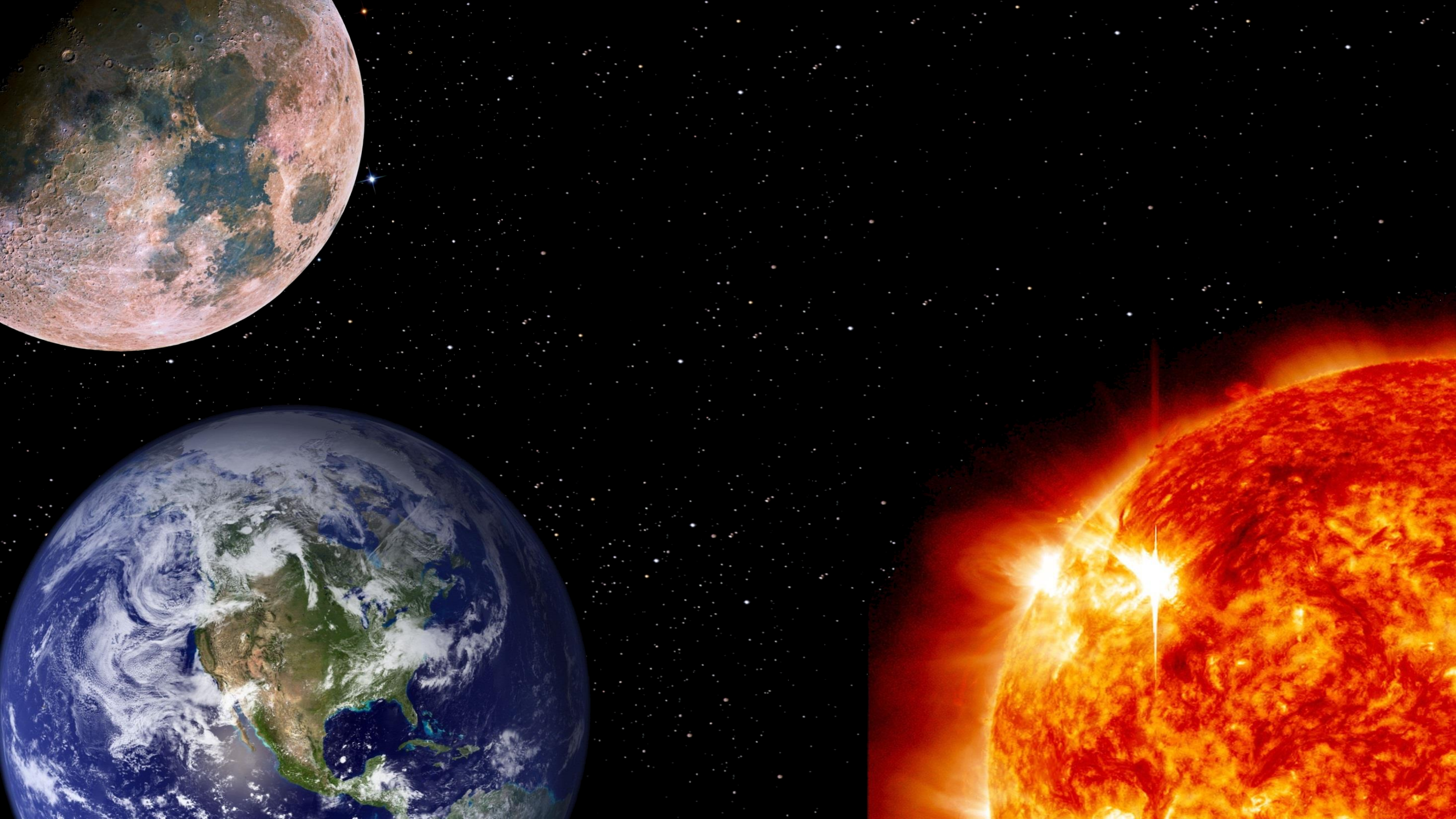
Implementation
- Owners engineer
- Bankability assessment
- Procurement and commissioning support.
- Acceptance test




Policy → Production → Transmission & Distribution → Use

Let’s start with a quiz >>>>

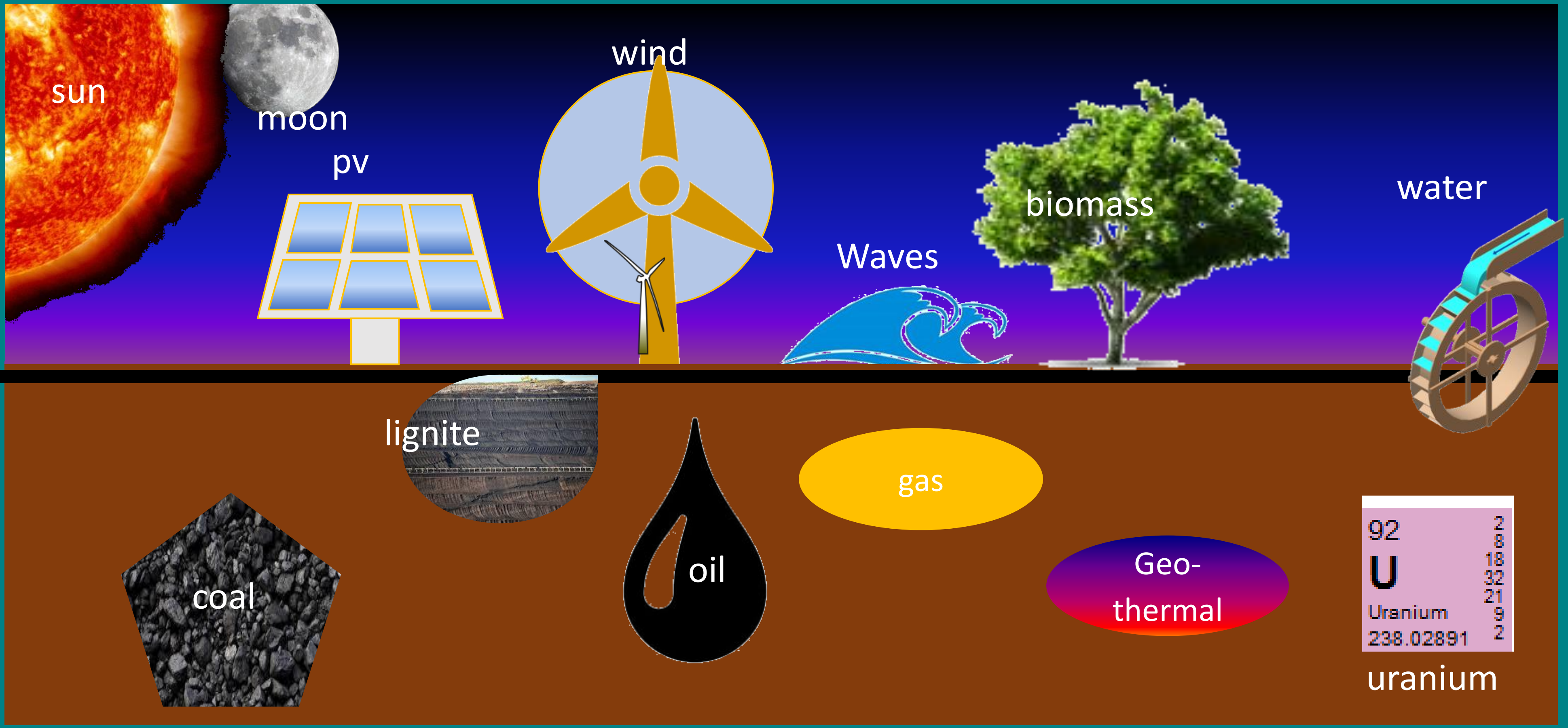
Name the three most important sources of sustainable energy.



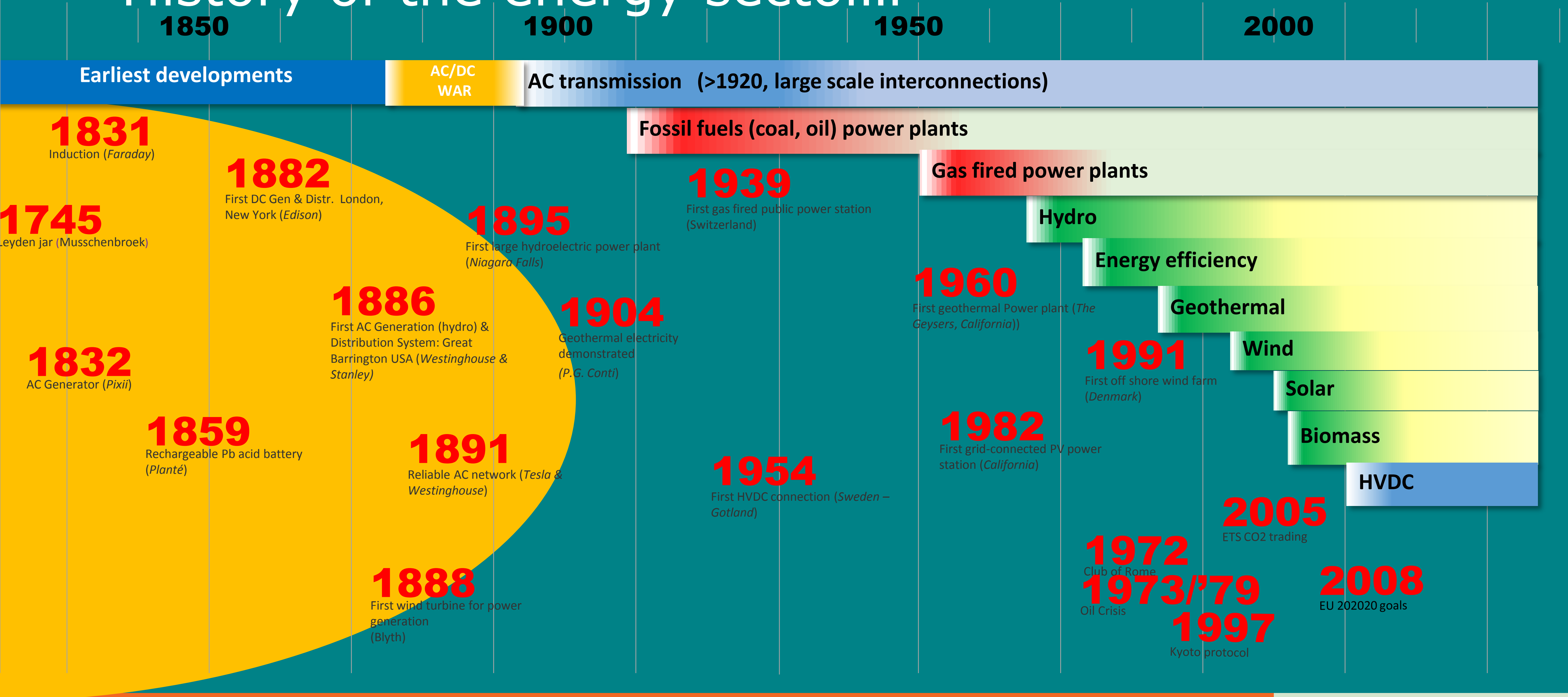
Where does the energy come from?

above ground

below ground



Energy transitions|
History of the energy sector…



Energy transitions| Major difference between past & current energy transition.

Transition periods in 19th and 20th century mainly driven by:

- growing welfare and

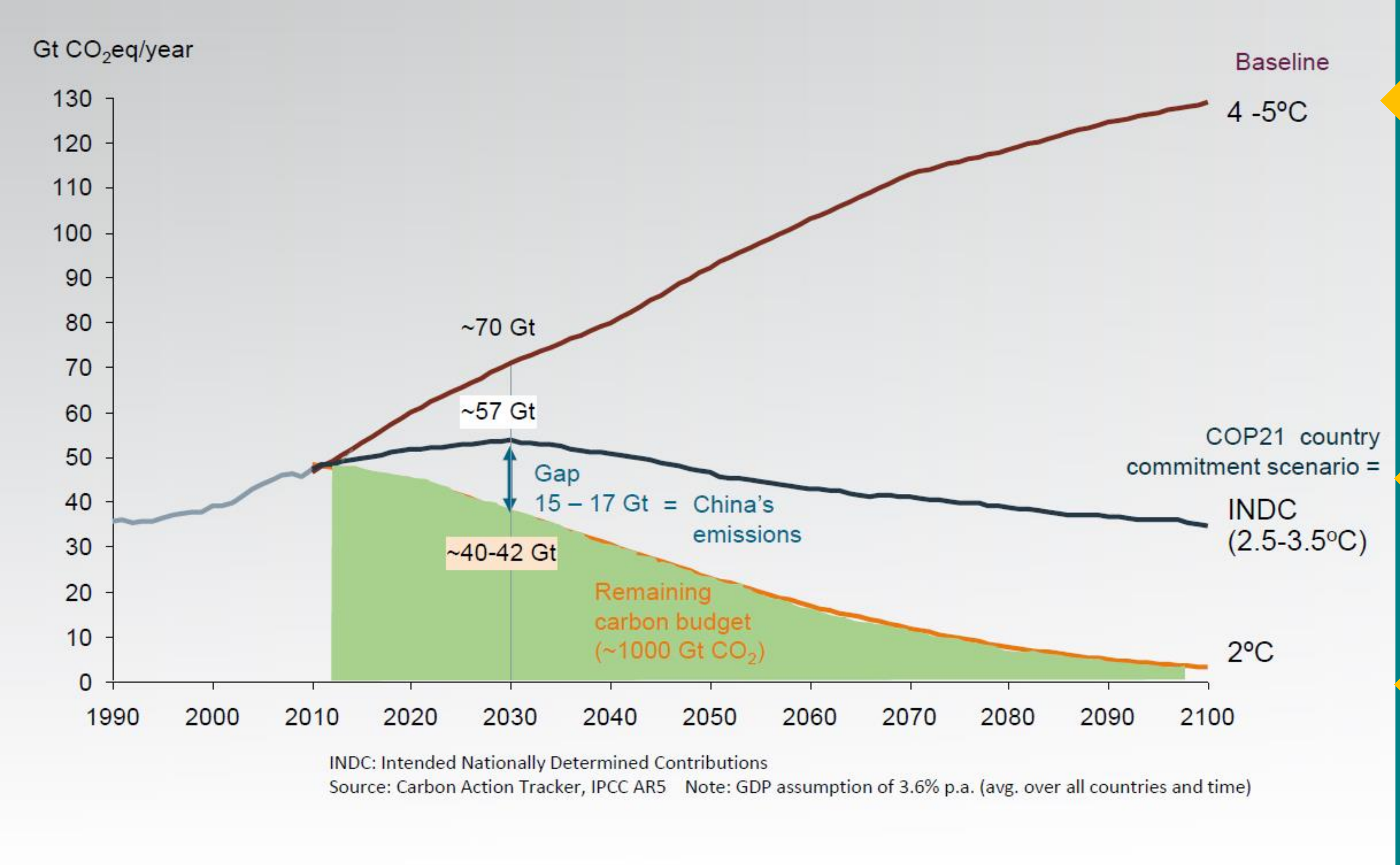
- a need for more electricity.

Today's energy transition is driven by the necessity to:

- decarbonize the electricity sector and

- the wish to be less dependent on exhaustible fossil fuels.

COP 21: Urgency



Consequences if no action is taken

Input from countries

Needed for max +2°C scenario

The world of energy: six major trends

1.
Increasing world population and welfare

2.
Increasing electricity demand

3.
Environmental issues and climate change

4.
Declining fossil fuel supplies

5.
Advancing technology

6.
Maintaining reliability

Challenge: affordable and reliable energy supplies to support sustainable economic development

COP 21 – Which agreement did we get?

Agnes Dudek

DNV GL – Business Assurance

04 February 2016

Ungraded

COP21 · CMP11
PARIS 2015
UN CLIMATE CHANGE CONFERENCE

195 countries adopted a historic climate agreement in December 2016 in Paris.

The climate deal sends a strong signal to business and investors that there is only one future direction of travel: to reduce emissions to keep global warming below 2 degrees Celsius.

How did we get there?

From top down to a bottom up regime

1992

Adoption of the UNFCCC

- International environmental treaty negotiated at the Earth Summit in Rio de Janeiro
- UNFCCC aims to stabilize GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

United Nations
Framework Convention on
Climate Change

From top down to a bottom up regime

1997

TOP-DOWN

Kyoto Protocol : world's first emission reduction treaty

- The 1997 Kyoto Protocol took a "top-down" and highly differentiated approach.
- It established binding emissions targets for developed countries, and no new commitments for developing countries.

The goal of Kyoto was to reduce carbon emission from 1990 level by

5%

From top down to a bottom up regime

2009 & 2010

BOTTOM-UP :

Copenhagen COP15 & Cancun COP16

- With the 2009 Copenhagen Accord and 2010 Cancún Agreements, countries established a parallel “bottom-up” framework.
- This approach attracted much wider participation, including, for the first time, specific mitigation pledges by developing countries.

From top down to a bottom up regime

2011 & 2013

Moving toward Paris
Durban COP 17 and Warsaw COP 19

- The negotiations toward a COP 21 were launched with the Durban Platform at COP 17 in 2011.
- COP 19 called on parties to submit INDCs before COP 21, signaling an important bottom-up feature of the emerging agreement.
- Heading into Paris, > 180 countries (90% of global emissions) had submitted INDCs, a much broader response than many had anticipated.

From top down to a bottom up regime

December 2015

COP21 – Paris climate agreement

- COP21 reached a historic agreement, setting a fundamentally new course in the two-decade-old global climate effort.
- The new treaty ends the strict differentiation between developed and developing countries .
- It creates a framework that commits all countries to put forward their best efforts and to strengthen them in the years ahead.
- This requires, for the first time, all parties to report regularly on their emissions and implementation efforts, and undergo international review.

Which agreement did we get in Paris?

Intended Nationally Determined Contribution (INDC)

INDC

An INDC identifies the actions a national government intends to take under the Paris Climate Change Agreement.

In their INDCs, countries outline the steps they are taking or will take to reduce emissions at national level.

INDCs are the basis of post-2020 global emissions reduction commitments that is included in the Paris climate agreement.

188 out of 196 UNFCCC member states provided Intended NDCs with 2025 targets. These will be replaced by new NDCs by 2020.

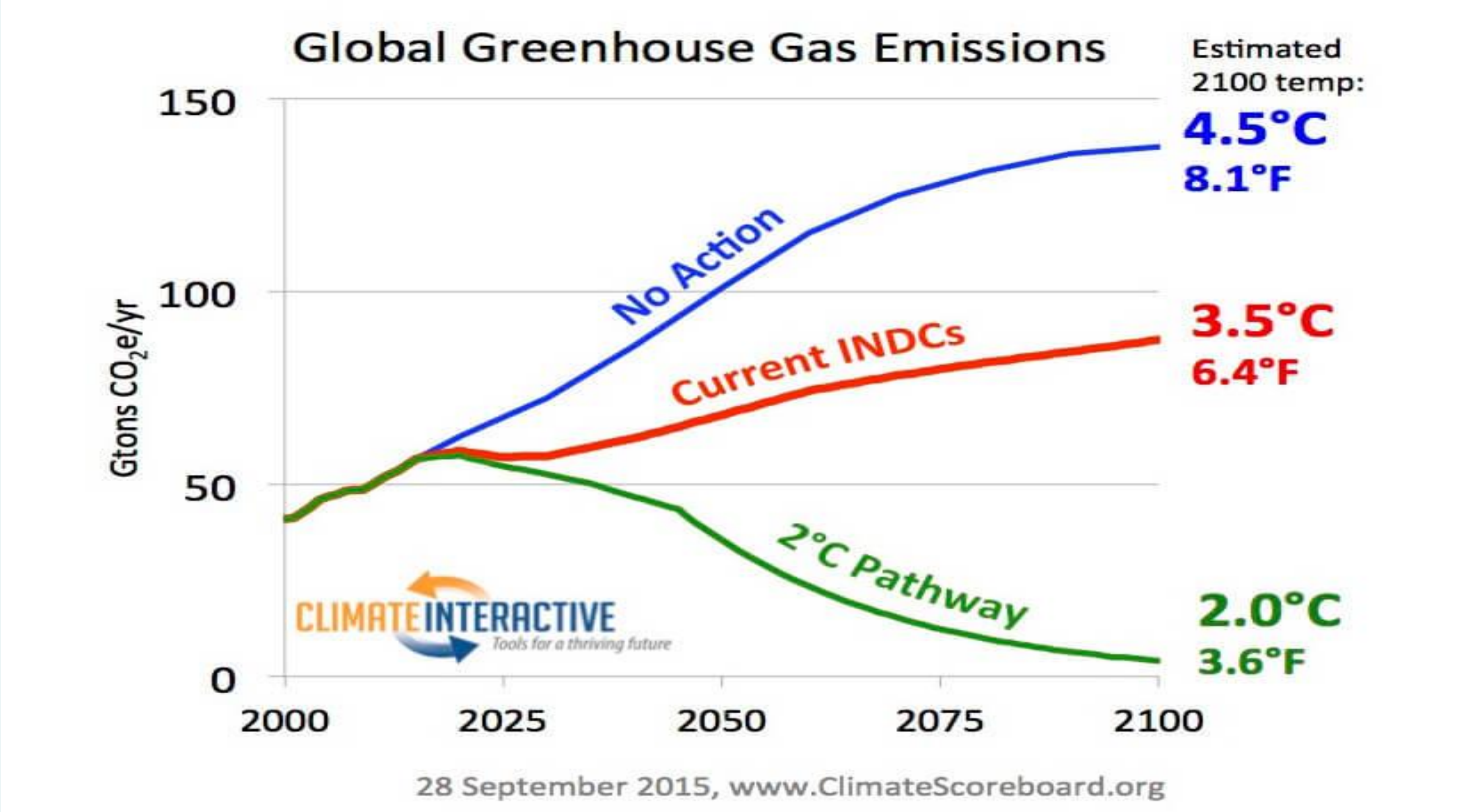
Under the Paris Climate Change Agreement, all countries committed to submit new NDCs every five years, with the clear expectation that they will “represent a progression” beyond previous ones.

Still a huge gap between current NDCs (pledges equal 2,7 - 3,3°C) and a 2°C path.

Synthesis report: http://unfccc.int/focus/indc_portal/items/9240.php

Intended Nationally Determined Contribution (INDC)

INDC



Paris agreement key points

Temperature

Reaffirm the goal of limiting global temperature increase well below 2 degrees Celsius, while urging efforts to limit the increase to 1.5 degrees

NDC

Establish binding commitments by all parties to make "nationally determined contributions" (NDCs), and to pursue domestic measures aimed at achieving them.

Transparency and accountability (2018)

Commit all countries to report every 2 year on their emissions and "progress made in implementing and achieving" their NDCs, and to undergo international review.

Stocktake and successive NDCs

Commit all countries to submit new NDCs every five years, with the clear expectation that they will "represent a progression" beyond previous ones;

Differentiation

Reaffirm the binding obligations of developed countries under the UNFCCC to support the efforts of developing countries, while for the first time encouraging voluntary contributions by developing countries too;

Carbon market

Call for a new mechanism, similar to the Clean Development Mechanism under the Kyoto Protocol, enabling emission reductions in one country to be counted toward another country's NDC.

Timeline for signature and ratification of the Paris Agreement

Parties can join by signing the Agreement and depositing instruments of "ratification, acceptance or approval"

Parties can join by "accession"

DECEMBER 12, 2015

COP21
Paris Agreement adopted by 196 Parties to the UNFCCC

APRIL 22, 2016

Paris Agreement is opened for signing

APRIL 21, 2017

Deadline for signing

When Will the Paris Agreement Take Effect?

At least **55** PARTIES TO THE UNFCCC representing at least **55%** OF TOTAL GLOBAL GHGS must sign on.

COP21- What's next for business?

What's next for investors?

Investors

Understand and address climate & carbon risks

The agreement should give investors across the world the confidence to do much more to understand and address the risks arising from high carbon assets and climate risks (physical, regulation, reputation etc…).

Seek new opportunities linked to the low carbon transition

The agreement will create an environment for more innovation of low carbon solutions across sectors and create new investment opportunities.

Increase disclosure requirements

Demand from companies more disclosure related to their climate risks exposure and strategy as well as reporting quality of GHG emissions (ref FSB and CDP) .

What's next for companies?

Companies

Reduce the impact climate change

The climate deal is a strong step that signals to business that the nations of the world are serious about reducing the impacts of climate change

Reduce own emission

The next step for businesses is to decrease their own emissions.

There will be a increase demand from external stakeholders or regulations to decrease emissions. (Ref EU ETS)

Understand climate risks

It will become increasingly important for companies to map and understand their climate risks exposure.

Integrate climate strategy with business strategy

Prepare businesses for the transformation towards a low carbon economy.

GEOCAP

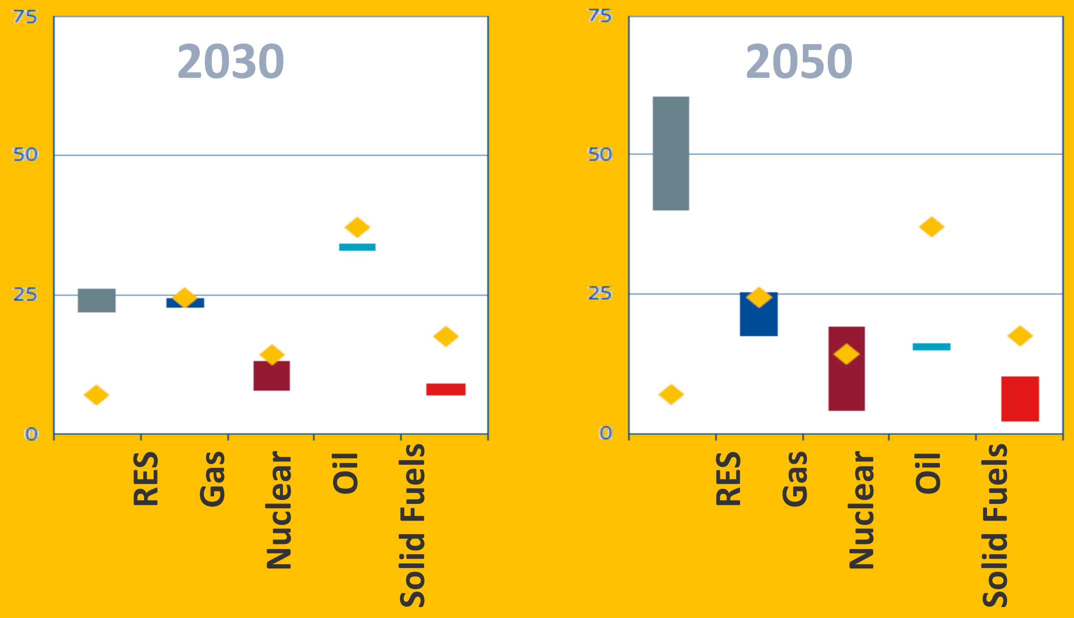
Geothermal Capacity Building Program Indonesia - Netherlands

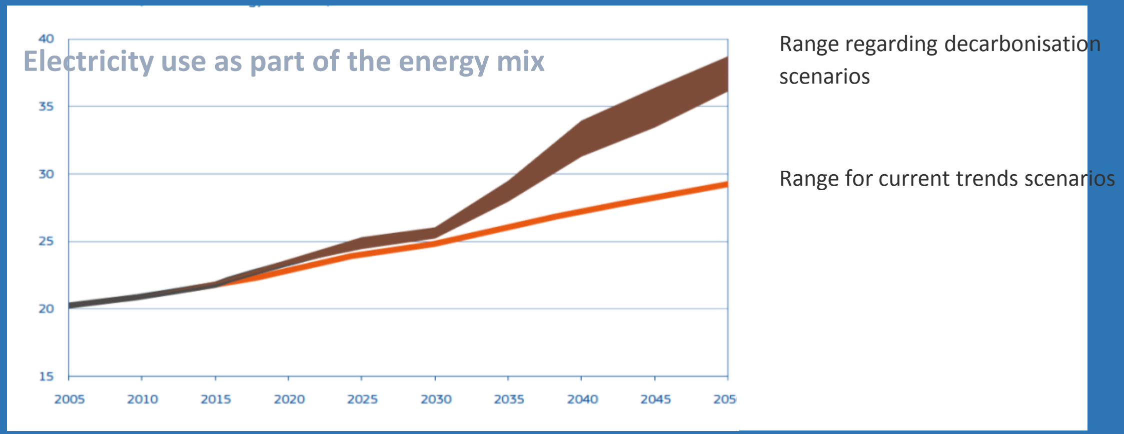
March 2016, Bandung

The effect of high RES penetration in the grid

Pre-workshop ITB

High RES penetration |Energy scenarios change (again) the energy mix (Roadmap 2050 EU)





100% RES…?

EU decarbonisation scenarios changing the energy mix

"20-20-20" targets: 20% reduction greenhouse emissions; 20% RES and 20% improvement EU's energy efficiency.

Increasing trend

Share of electricity in current trend and decarbonisation scenario's (% of final energy demand)

Energy Roadmap 2050, European Commission

High RES penetration |

Day – Night & seasonal imbalance

High RES penetration |
Intermittency – imbalance supply / demand

High RES penetration |
Instruments to allow high RES penetration……

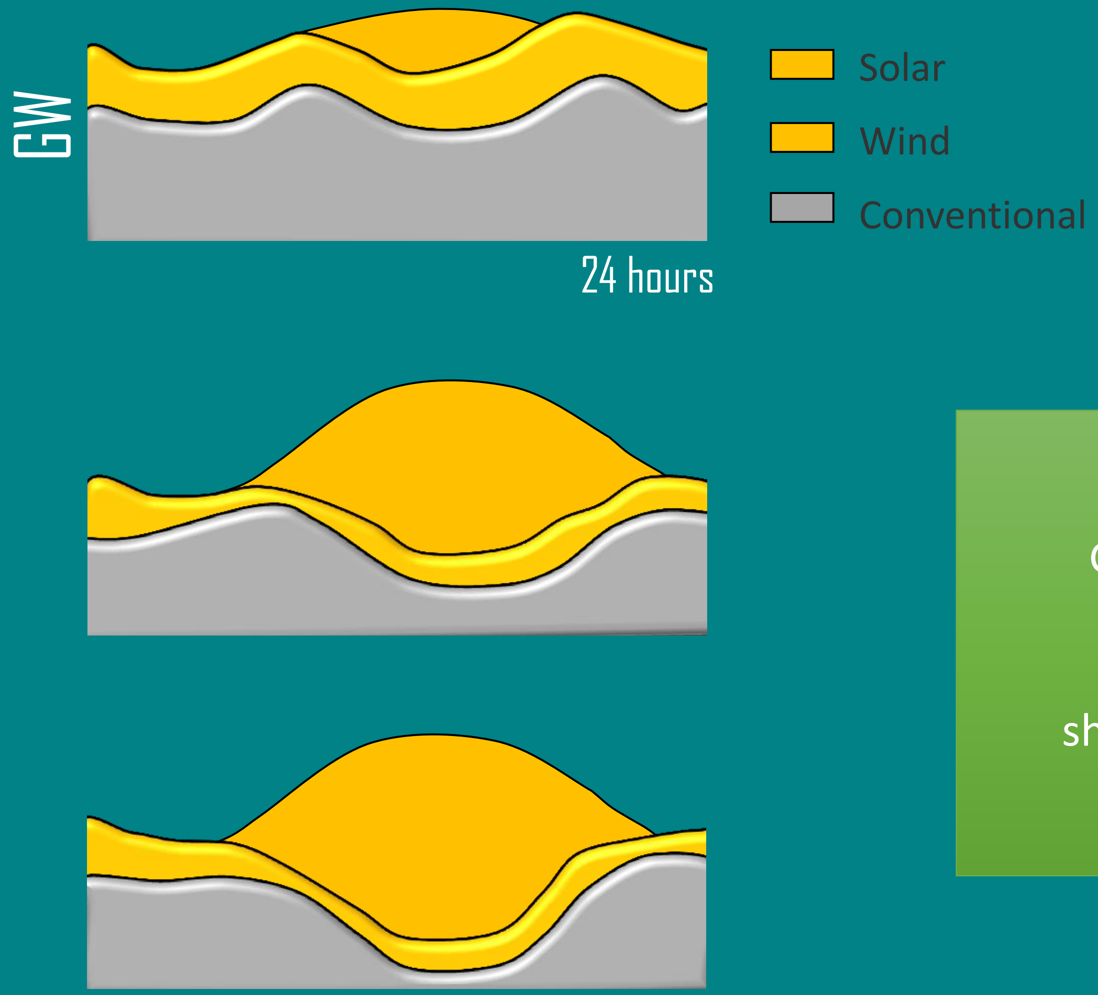
Flexible Power

Demandside management

Energy storage

Supergrid

High RES penetration | Eating the baseload…..

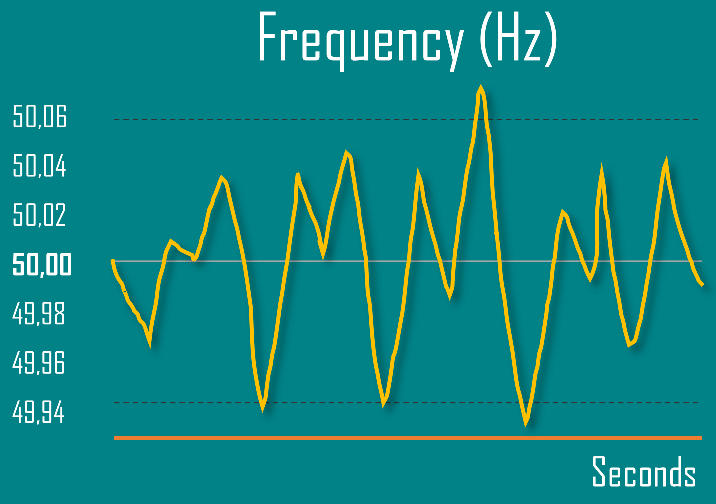


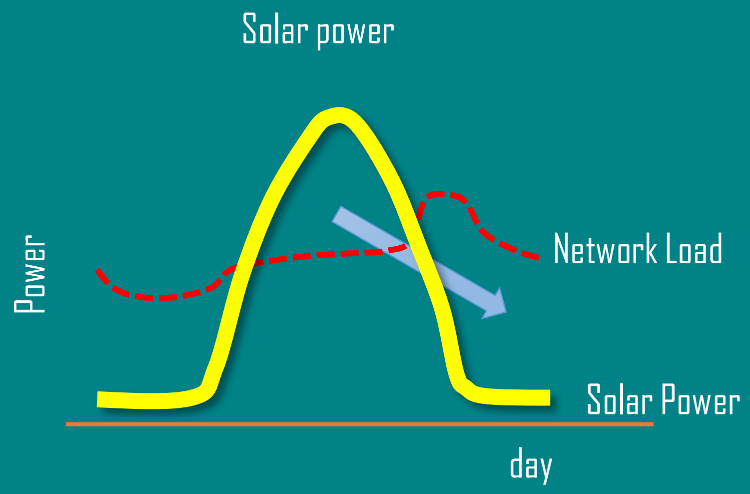
German load curves with (simulated) double the penetration of wind and solar,

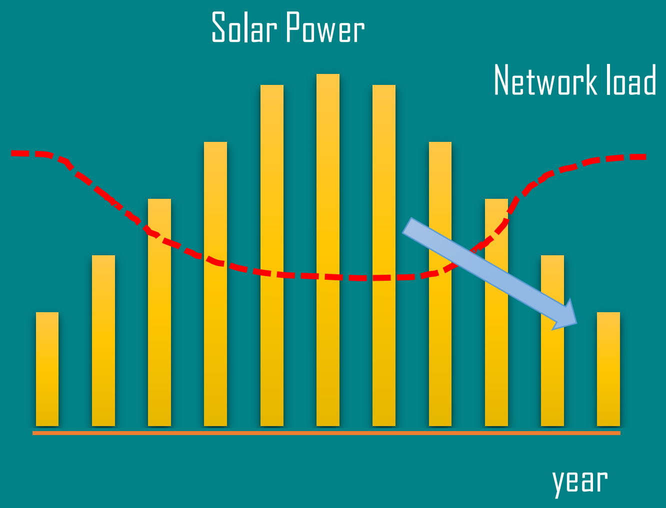
showing the disruption to baseload and energy mix

Source: Citi Research

Grid imbalance | Different time scales







Second based control

- Ancillary services
- Primary/Secondary reserve

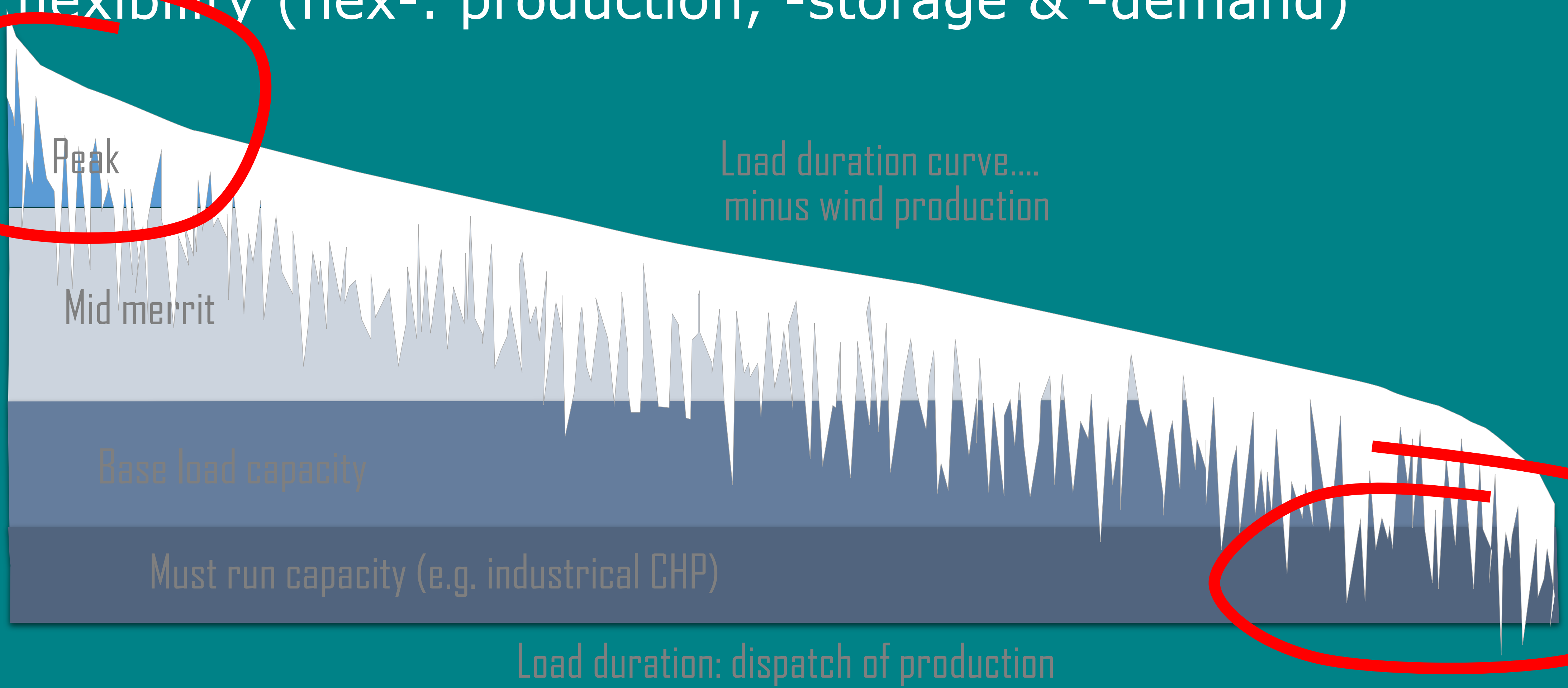
Day- load shifting

- Energy Management Systems

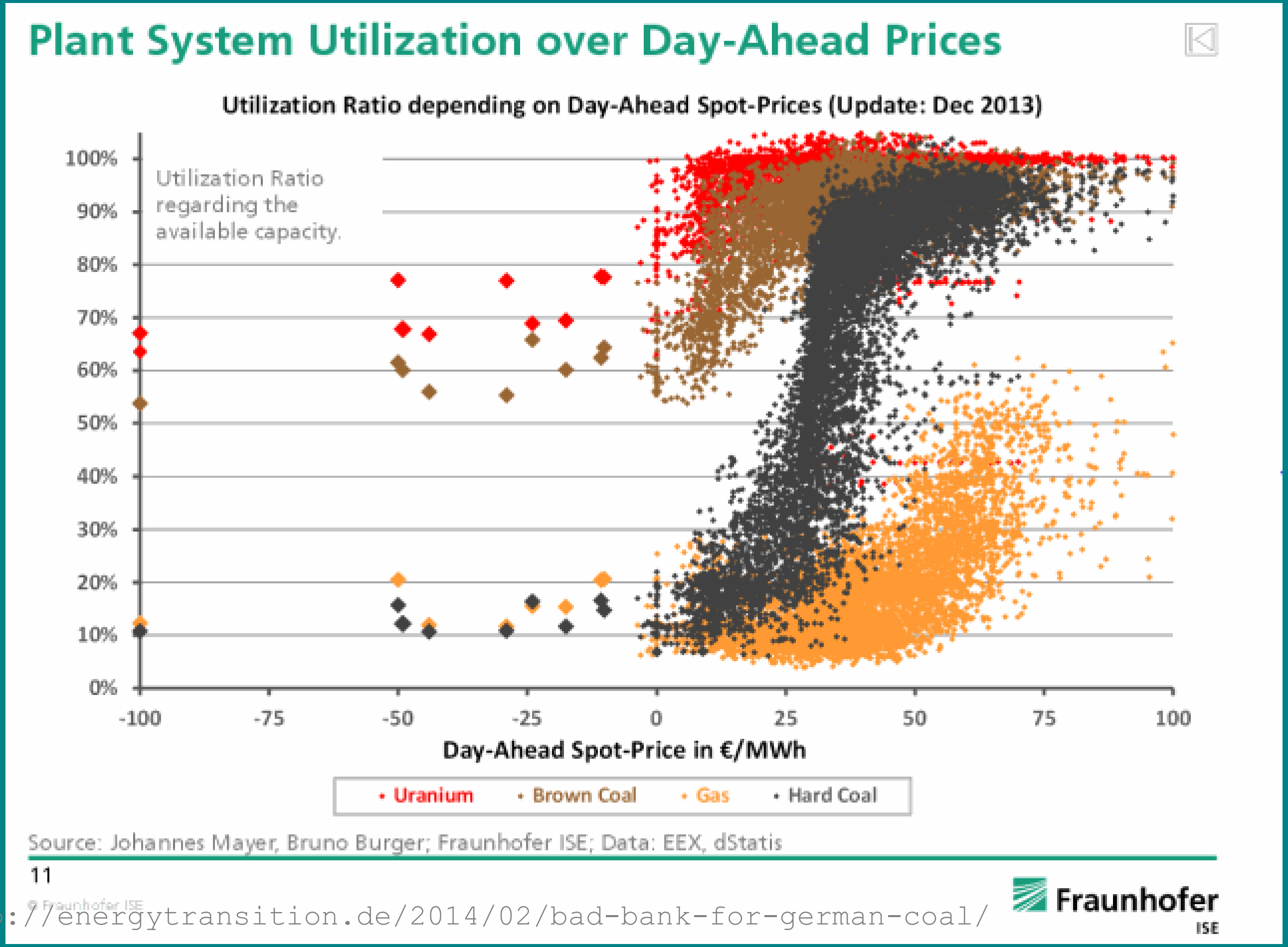
Seasonal load shifting

- Hydro storage

Chain optimization needed | intermitted sources need flexibility (flex-. production, -storage & -demand)



Merit order by capacity factor plot, based on Day-Ahead prices



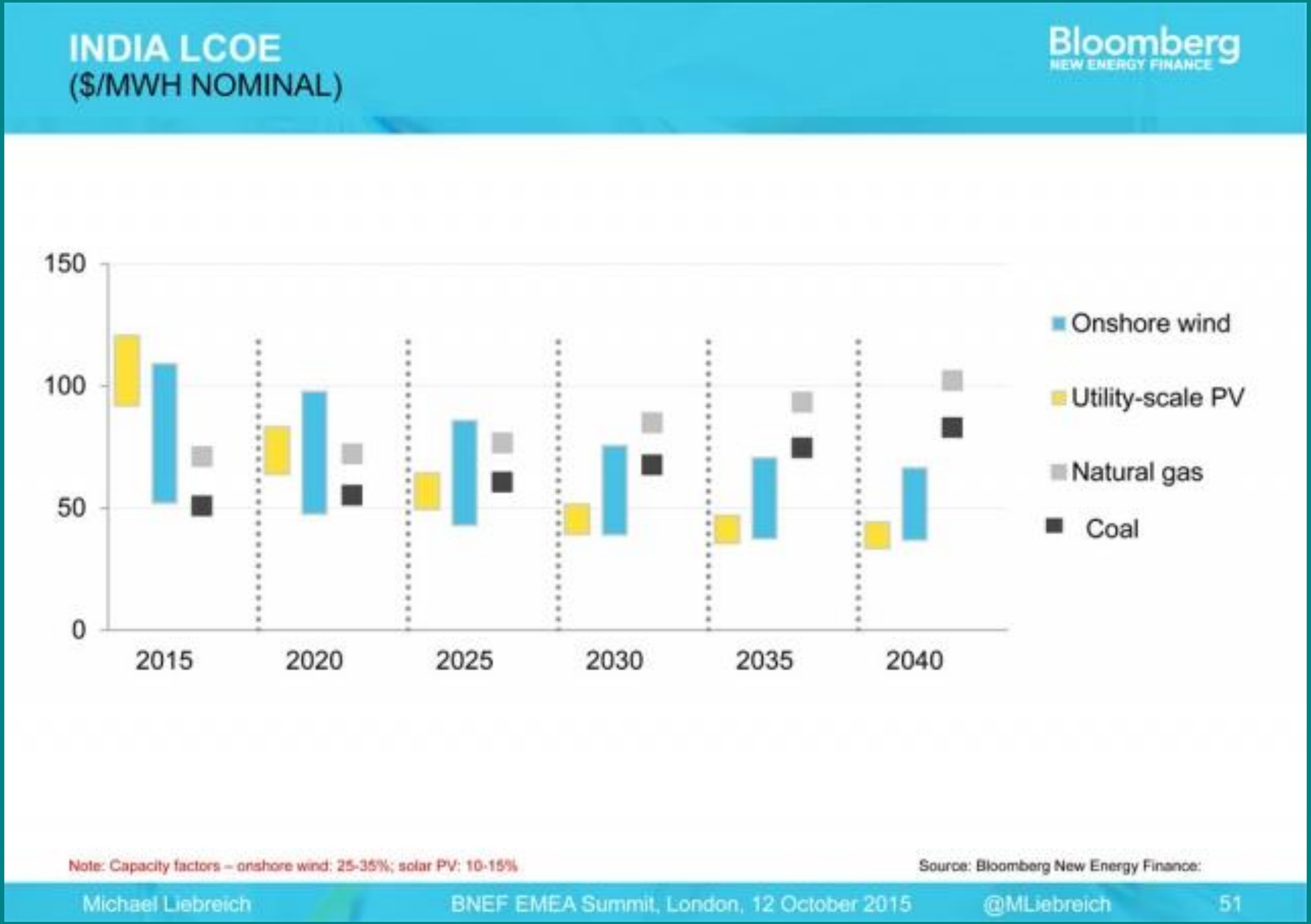
http://energytransition.de/2014/02/bad-bank-for-german-coal/

Plant system utilisation (Capacity factor)

Plants higher in the graph, have lower marginal cost per kWh and will be used more often.

- **Uranium**: 100%-80% (→cheaper to sell for negative price levels than to lower the 80% CF)
- **Brown coal:** 100%-60%
- **Hard coal:** 100%-10%
- **Gas:** 60%-5% (Smallest amount of fulload hours for gasfired power plants).

LCOE prediction in India from 2015 till 2040



Ref: Bloomberg 2015

U.S. average levelized cost ($/MWh) for plants entering service in 2020

Plant type	Capacity factor (%)	Levelized capital cost	Fixed O&M	Variable O&M (including fuel)	Transmission investment	Total system LCOE
Dispatchable Technologies						
Conventional Coal	85	60.4	4.2	29.4	1.2	95.1
Advanced Coal	85	76.9	6.9	30.7	1.2	115.7
Advanced Coal with CCS	85	97.3	9.8	36.1	1.2	144.4
Natural Gas-fired						
ConventionalCombined Cycle	87	14.4	1.7	57.8	1.2	75.2
Advanced Combined Cycle	87	15.9	2.0	53.6	1.2	72.6
Advanced CC with CCS	87	30.1	4.2	64.7	1.2	100.2
Conventional Combustion Turbine	30	40.7	2.8	94.6	3.5	141.5
Advanced Combustion Turbine	30	27.8	2.7	79.6	3.5	113.5
Advanced Nuclear	90	70.1	11.8	12.2	1.1	95.2
Geothermal	92	34.1	12.3	0.0	1.4	47.8
Biomass	83	47.1	14.5	37.6	1.2	100.5
Non-Dispatchable Technologies						
Wind	36	57.7	12.8	0.0	3.1	73.6
Wind – Offshore	38	168.6	22.5	0.0	5.8	196.9
Solar PV[3]	25	109.8	11.4	0.0	4.1	125.3
Solar Thermal	20	191.6	42.1	0.0	6.0	239.7
Hydroelectric[4]	54	70.7	3.9	7.0	2.0	83.5

https://www.eia.gov/forecasts/aeo/electricity_generation.cfm

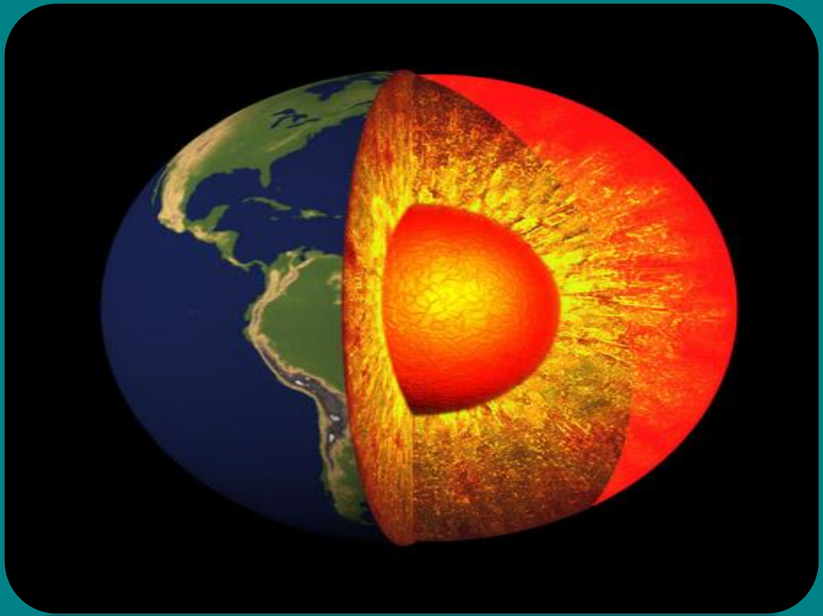
March 2016, Bandung

Geothermal energy

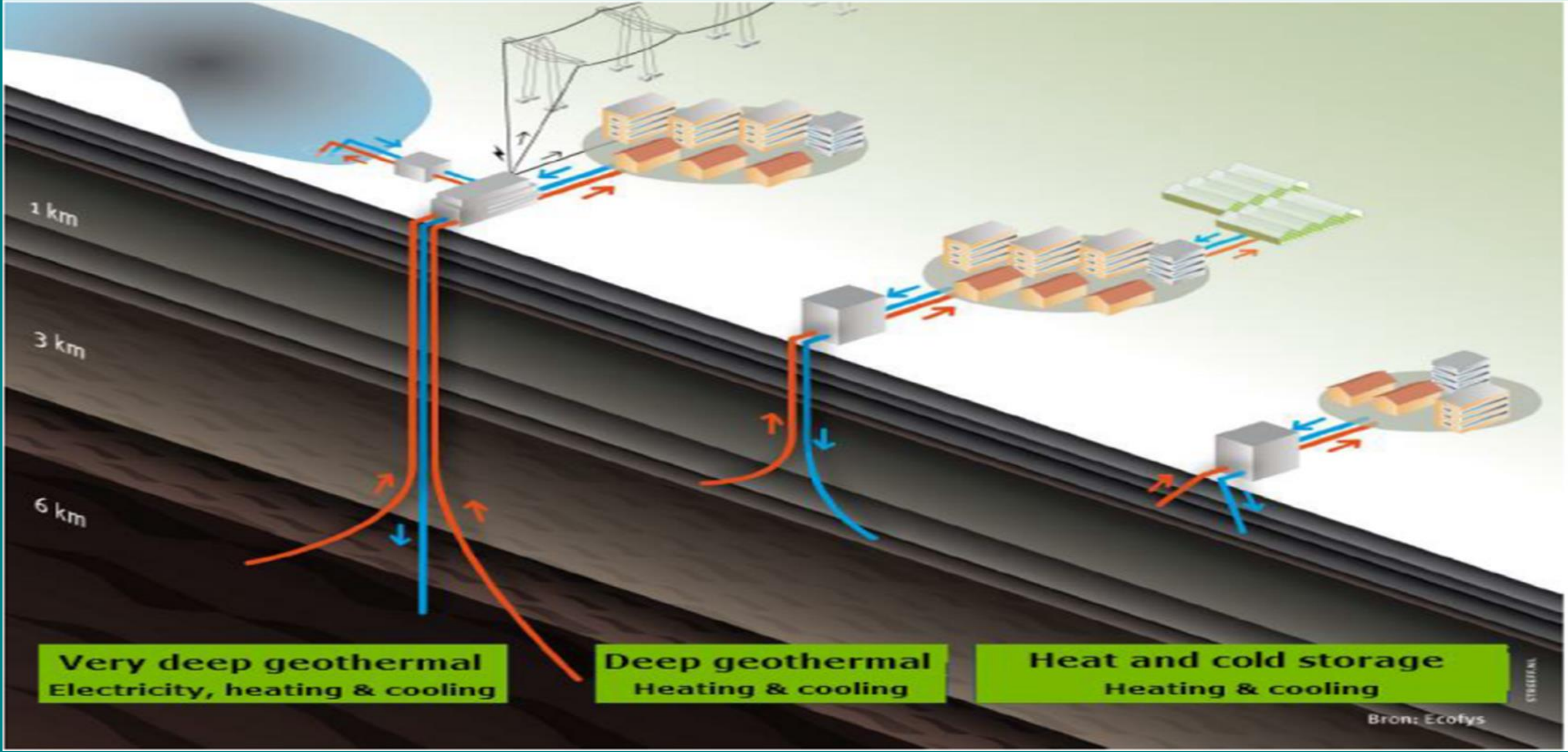
Pre-workshop ITB

What is geothermal energy?

- Geothermal energy is derived from hot water within the subsurface of the earth.
- The heat originates from different processes within the core of the earth at a depth of 5,000 to 6,500 km. (core temperature: >5,000ºC!)
- Temperature increases with depth, and depends on location.
- To use geothermal energy for electricity production, a geothermal steam turbine is needed.



What is Geothermal energy



Geothermal energy (you-tube movie)

https://www.youtube.com/watch?v=O6r_3AgI49Y

Geothermal energy
Advantages and Challenges

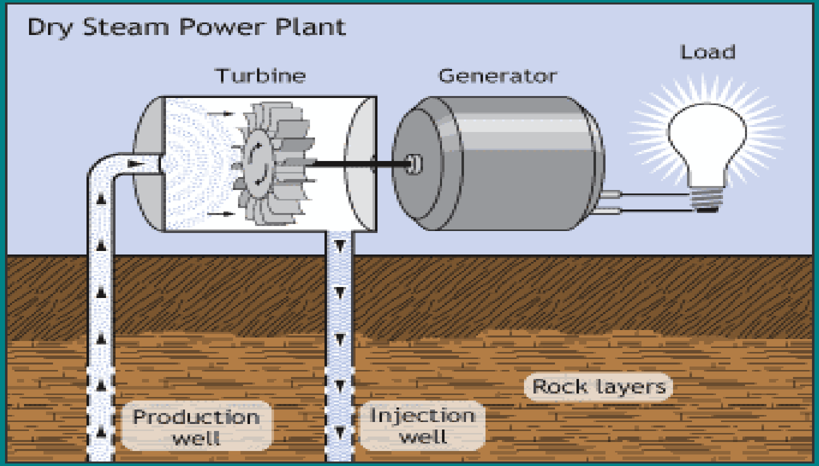
- **Advantages**
  - Sustainable energy source
  - Base load renewable energy production
  - No dependence on sunlight and wind
  - Promising economics, stable energy production price
  - Large production capacity potential and reserves: 38.000 PJ
  - No emissions into the environment
  - Acceleration in research and development

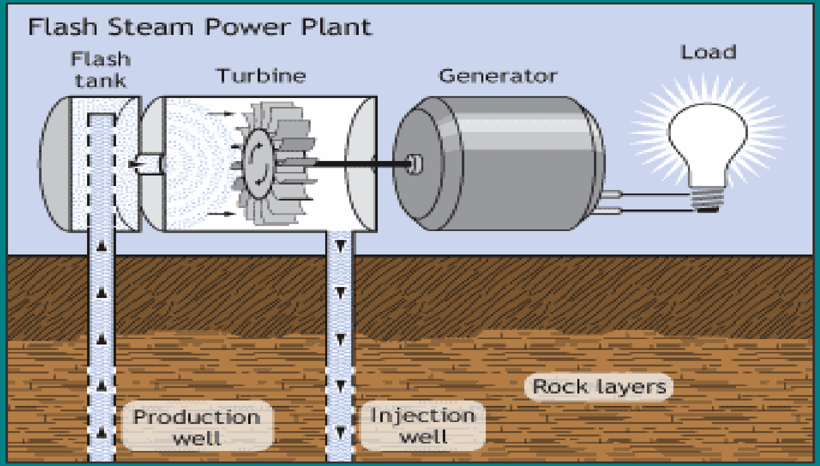
- **Challenges**
  - Large upfront investment required
  - Uncertainty during all project phases
  - Co-production of hydrocarbons
  - Economic feasibility differs with location
  - Public acceptance

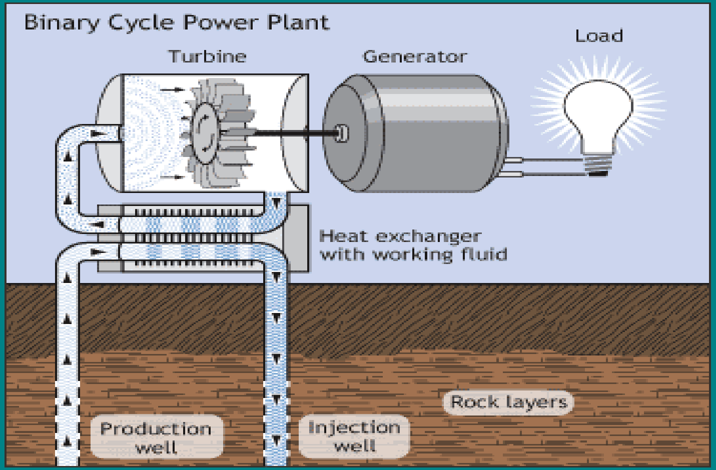
A geothermal power plant (you-tube movie)

https://www.youtube.com/watch?v=kjpp2MQffnw

Basic power plant cycles







- **Dry steam plant:**
  - Direct use of steam
  - Simple, inexpensive
  - Requires high temperature, low pressure reservoir

- **Flash steam plant:**
  - Direct use of brine after converting it to steam
  - Quite simple, inexpensive
  - Requires high temperature reservoir

- **Binary cycle plant:**
  - Indirect use brine (heat)
  - Simple
  - Lower temperature reservoir possible

- **And combinations of these basic cycles**

Basic power plant cycles

- Dry steam & single flash are mostly used

→ Electricity production

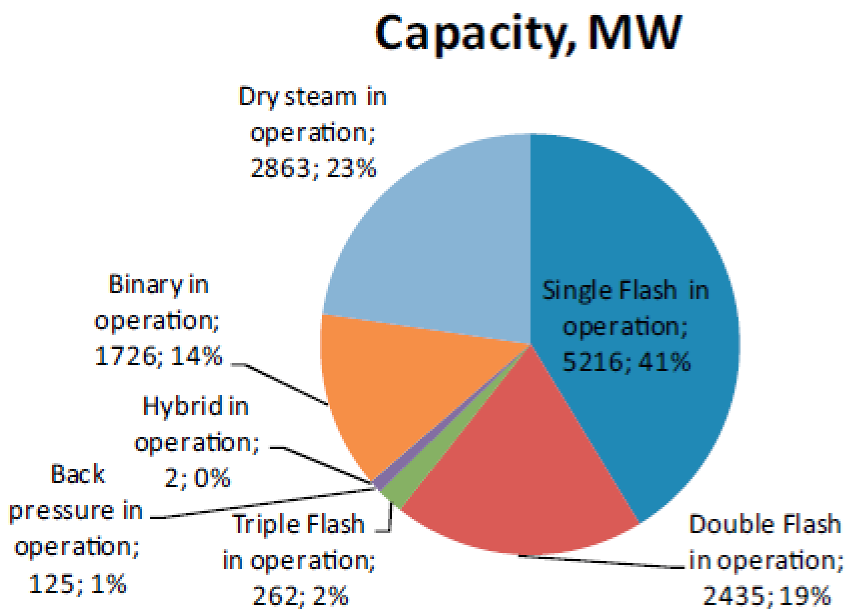


Fig. 3. Installed capacity in MWe (and%) for each plant typology (total 12,6 GWe).

Top five countries for the absolute increase in MWe since WGC2010.

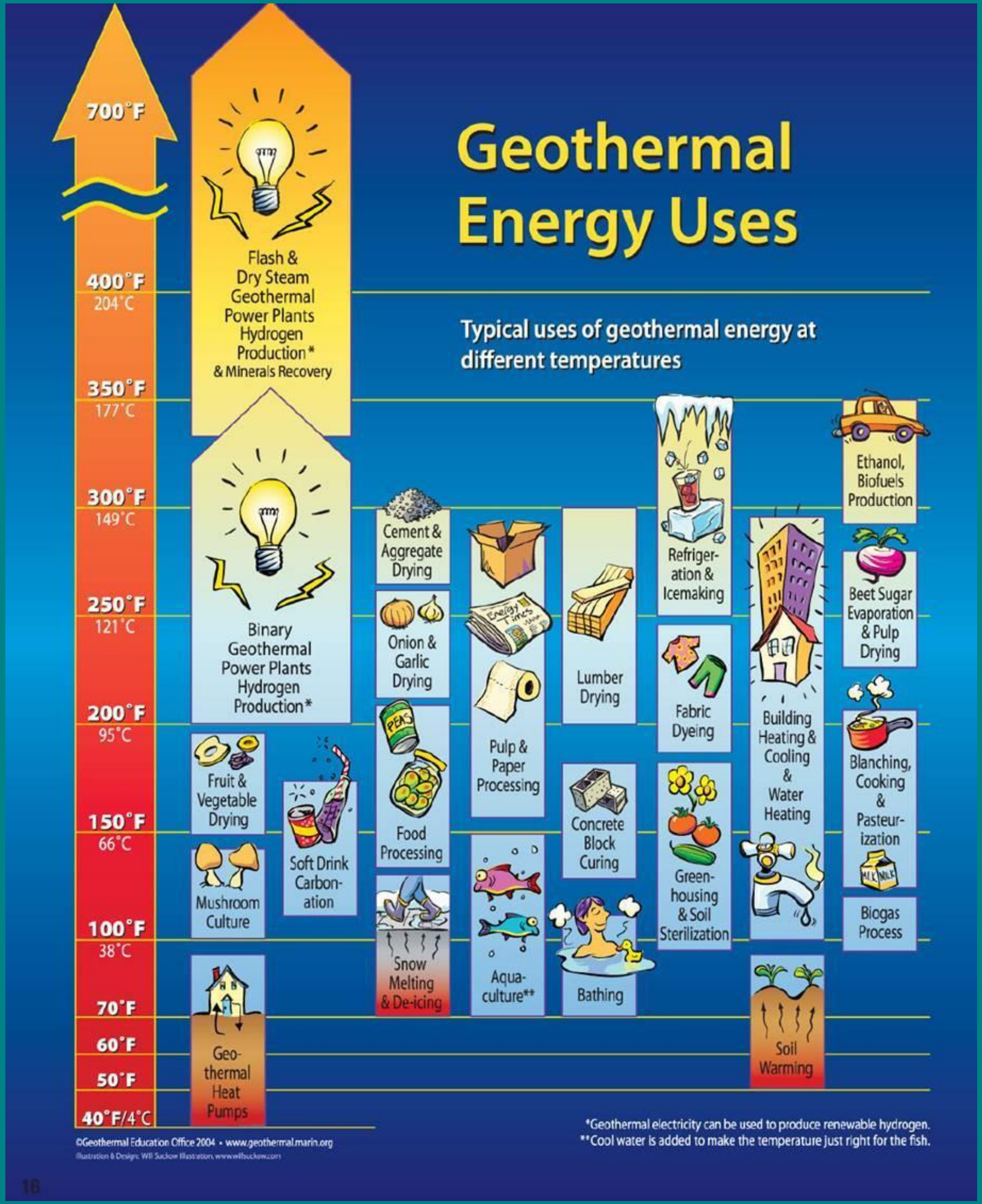
Country	MWe	GWh	%MWe	%GWh
Kenya	434	1.438	215%	101%
USA	352		11%	
Turkey	316	2.757	347%	563%
New Zealand	243	2.945	32%	73%
Indonesia	143		12%	

Top five countries for installed capacity in 2015.

Country	2010 MWe	2010 GWh	2015 MWe	2015 GWh
USA	3,098	16,603	3,450	16,600
Philippines	1,904	10,311	1,870	9,646
Indonesia	1,197	9,600	1,340	9,600
Mexico	958	7,047	1,058	6,071
New Zealand	762	4,055	1,005	7,000

Lindal diagram

Alternative uses of heat



Geothermal energy
Barriers

- Capital costs for geothermal power projects are as much as two or three times the cost per MW of fossil fuel generation
- Due to exploration and drilling expenses which also contain the highest risks as the true potential of the resource is not yet known at this stage

However: raw fuel costs and operational and maintenance cost are very low.

→ cost competitive with conventional forms of energy on a life-cycle basis

Investors tend to favour technologies with lower capital costs as a fraction of total cost because of the lower initial financial risk

- even essentially guaranteed long term profitability does not offset the reasonable risk associated with the start up.
- public policy support for renewable energy sources has traditionally been biased in favour of wind and solar rather than geothermal in many countries

Successful Geothermal Development

Key Elements:

- Availability of sufficiently accurate geothermal resource data and other relevant information
- Supportive policies and regulations
- Access to suitable financing for the project developer